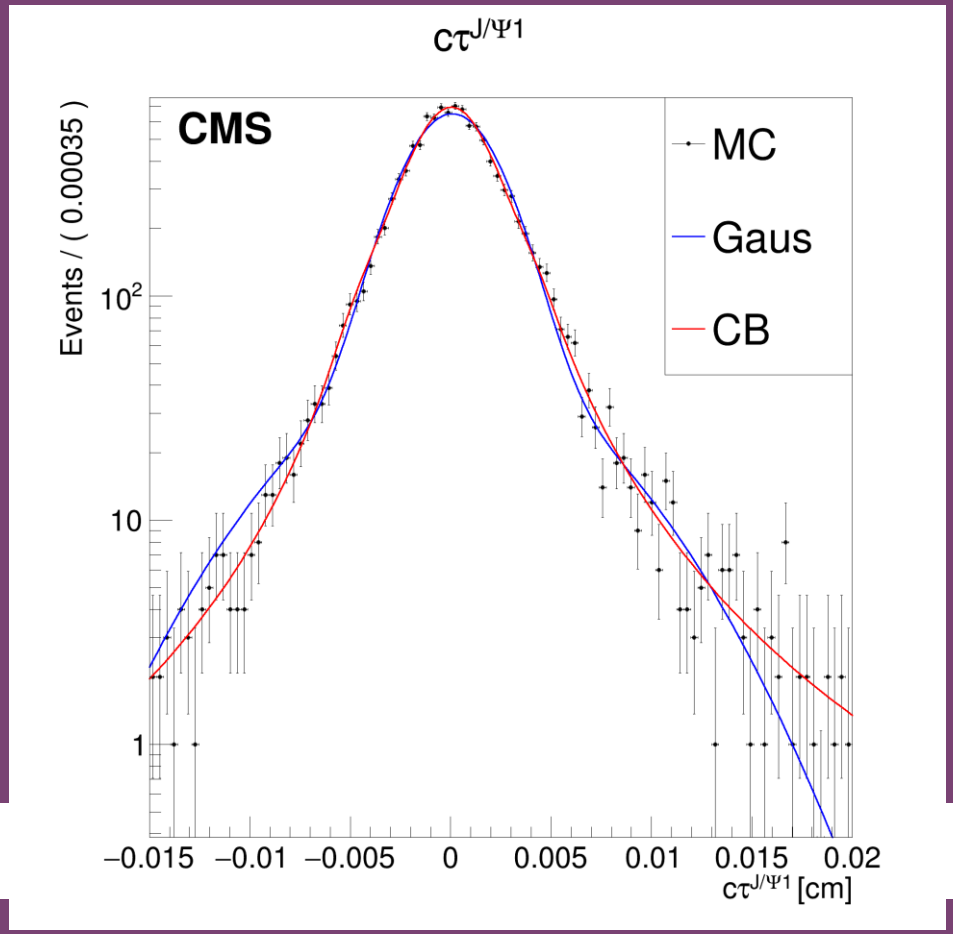
Fitting details

- 1. $c\tau$ p.d.f. for prompt $J/\psi J/\psi$ component
  - Double Gaussian or double CB



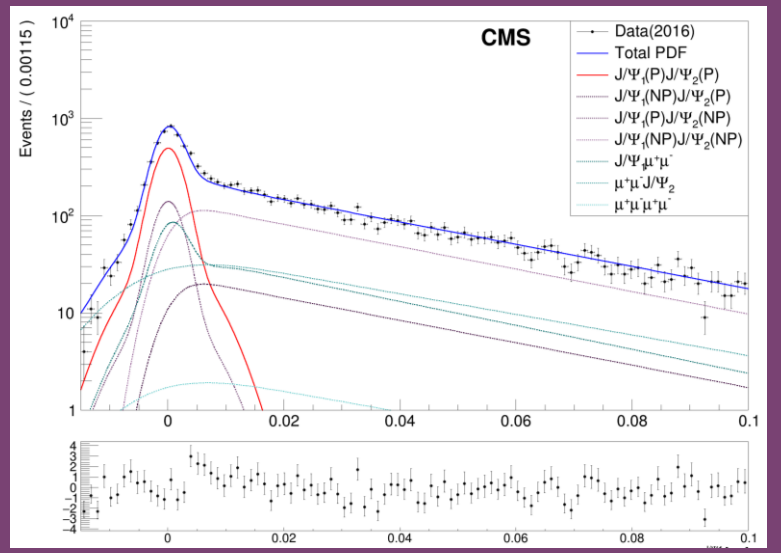
	Gaus	CB
NLL	-50983	-51031
Chi^2/ndf	1.68/4	0.91/7

Fitting details

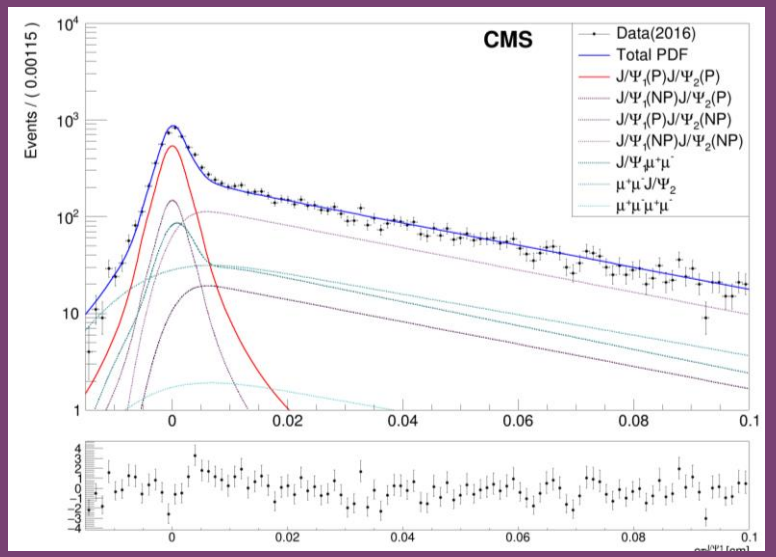
- 1. $c\tau$ p.d.f. for prompt $J/\psi J/\psi$ component
  - Double Gaussian or double CB

	Gaus	CB
NLL	-195865	-195872
Chi^2/ndf	1.24/4	1.24/4

P+P	2670 ± 60	2700 ± 60
P+NP	760 ± 30	740 ± 30
NP+NP	4310 ± 90	4300 ± 90
$J\mu\mu$	1570 ± 40	1570 ± 40
$\mu\mu\mu\mu$	100 ± 20	100 ± 20



Gaus



CB

$c\tau_1$

Fitting details

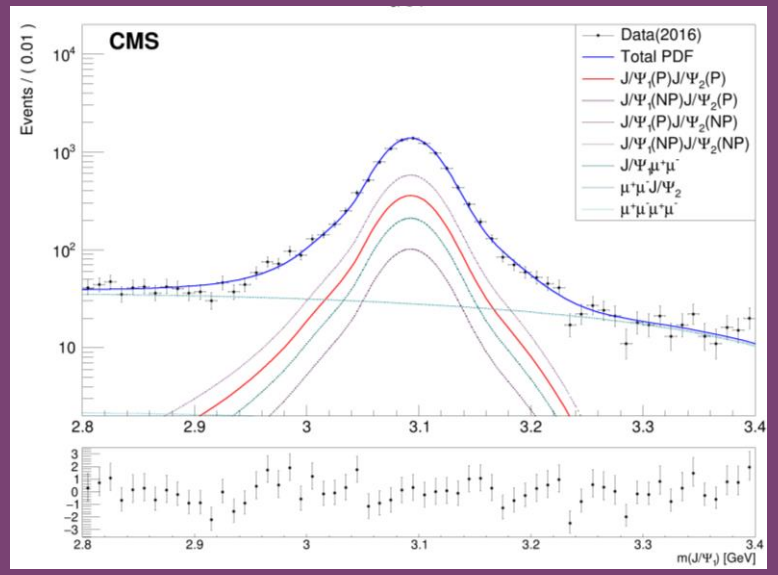
- 1. $c\tau$ p.d.f. for prompt $J/\psi J/\psi$ component
  - Double Gaussian or double CB
  - No big difference can be noticed from NLL (1D or 4D)
  - No big discrepancy can be found from the 4D fitting result
  - The Chi^2/ndf for double CB is abnormal (0.91/7)
  - Prefer double Gaussian for less parameters

Fitting details

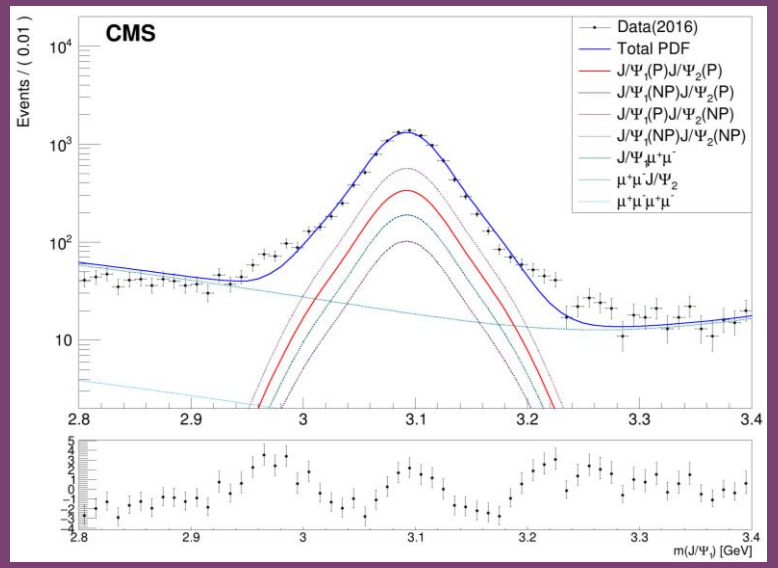
- 2. Mass p.d.f. for combinatorial component
  - Fix or not

	Fix	Float
NLL	-195865	-195711
Chi^2/ndf	0.90/10	2.85/12

P+P	2670 ± 60	2630 ± 60
P+NP	760 ± 30	780 ± 30
NP+NP	4310 ± 90	4420 ± 130
$J\mu\mu$	1570 ± 40	1480 ± 70
$\mu\mu\mu\mu$	100 ± 20	100 ± 30



Fix



Float

Fitting details

- 2. Mass p.d.f. for combinatorial component
  - Fix or not
  - No big difference can be noticed from NLL (slightly smaller with fixed parameters)
  - No big discrepancy can be found from the 4D fitting result
  - To float the parameters may cause trouble in binning fit
  - To fix the parameters has been tested
  - Propose to fixed the parameters

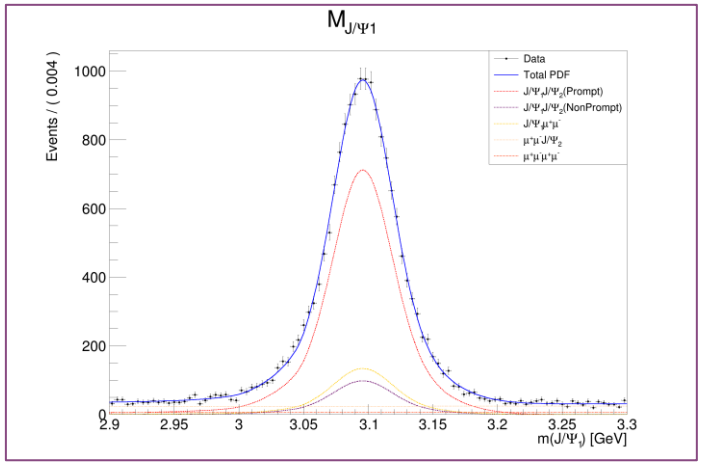
Fitting validation

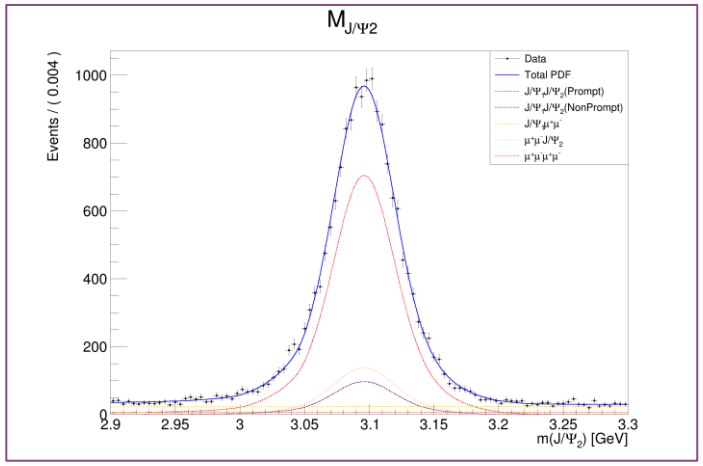
2022.11.10-12.1

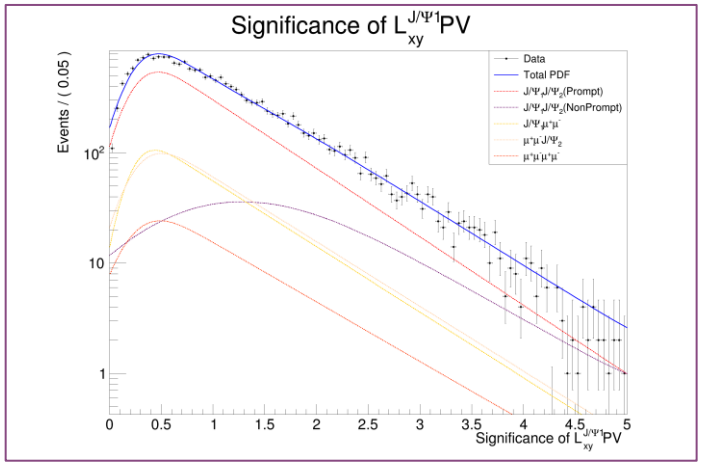
- 1. A previous trial
  - 8K SPS + 4K DPS + 2K B decay + 5K $J/\psi_1\mu^+\mu^-$ + 5K $\mu^+\mu^-J/\psi_2$ + 2K $\mu^+\mu^-\mu^+\mu^-$

MC

Generated





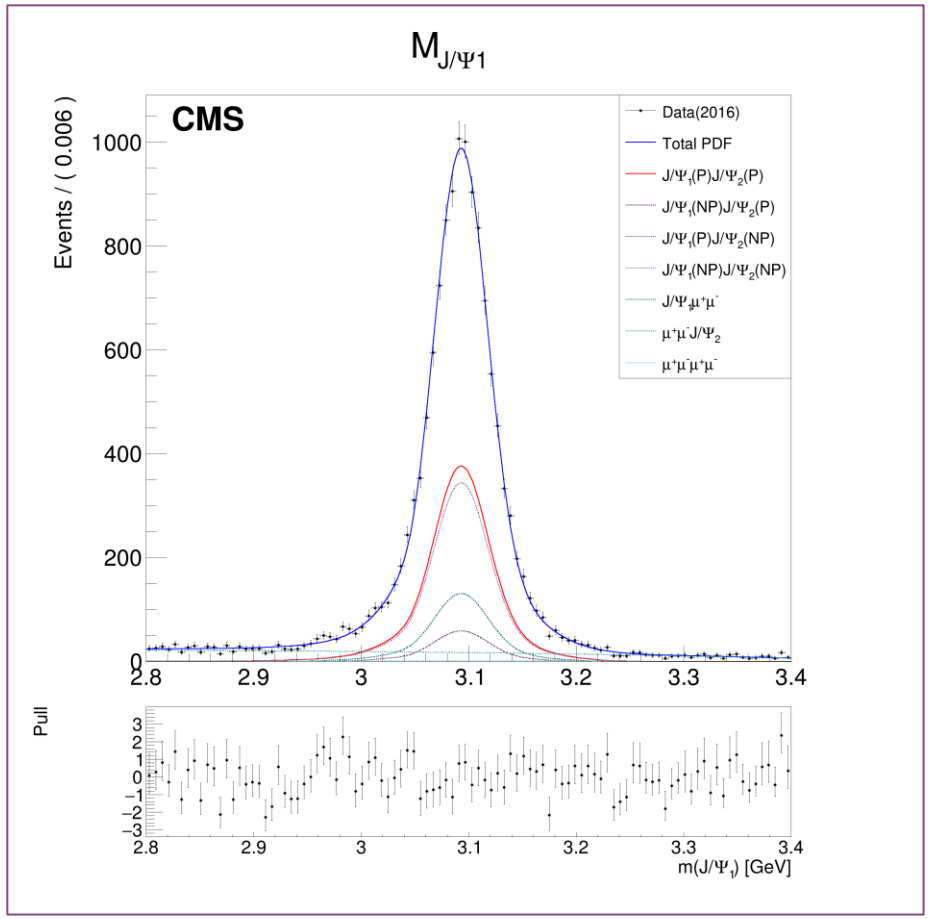


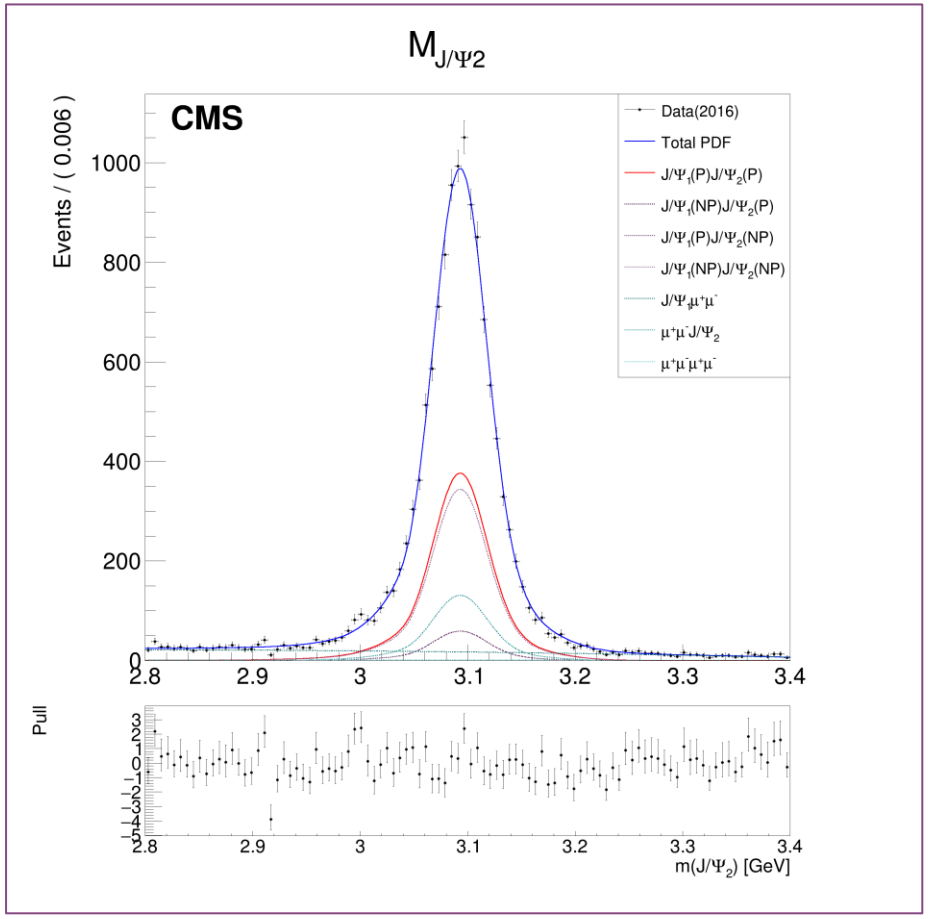
$J/\psi_1 J/\psi_2$(P)	$J/\psi_1 J/\psi_2$(NP)	$J/\psi_1\mu^+\mu^-$	$\mu^+\mu^-J/\psi_2$	$\mu^+\mu^-\mu^+\mu^-$
12600 ± 200	1700 ± 400	4700 ± 200	4820 ± 190	2500 ± 200

Fitting validation

- 2. Append MC samples to the dataset

2K SPS to
2016 dataset

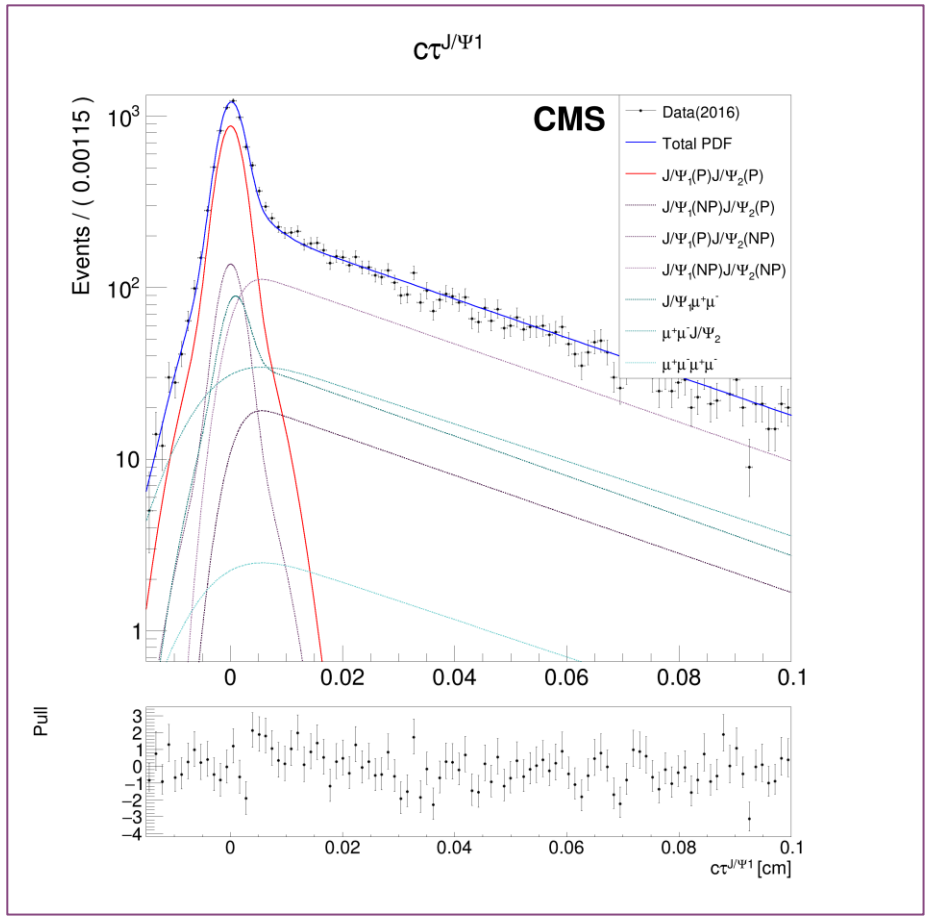


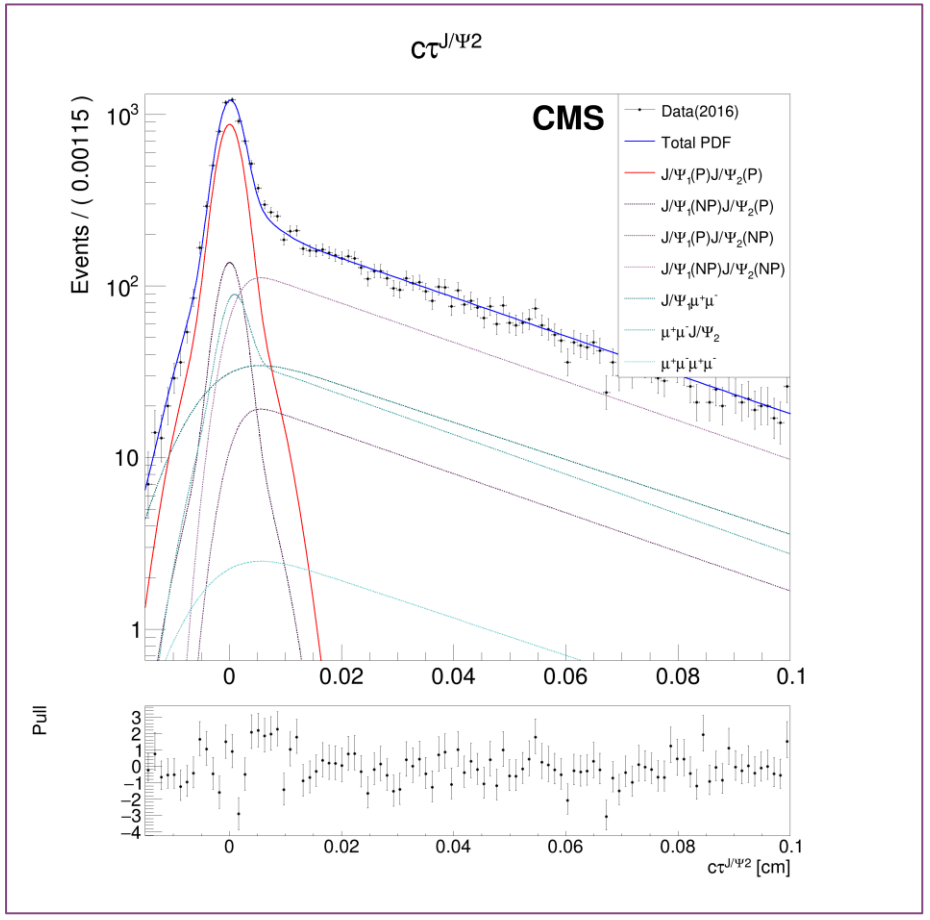


Fitting validation

- 2. Append MC samples to the dataset

2K SPS to
2016 dataset





Fitting validation

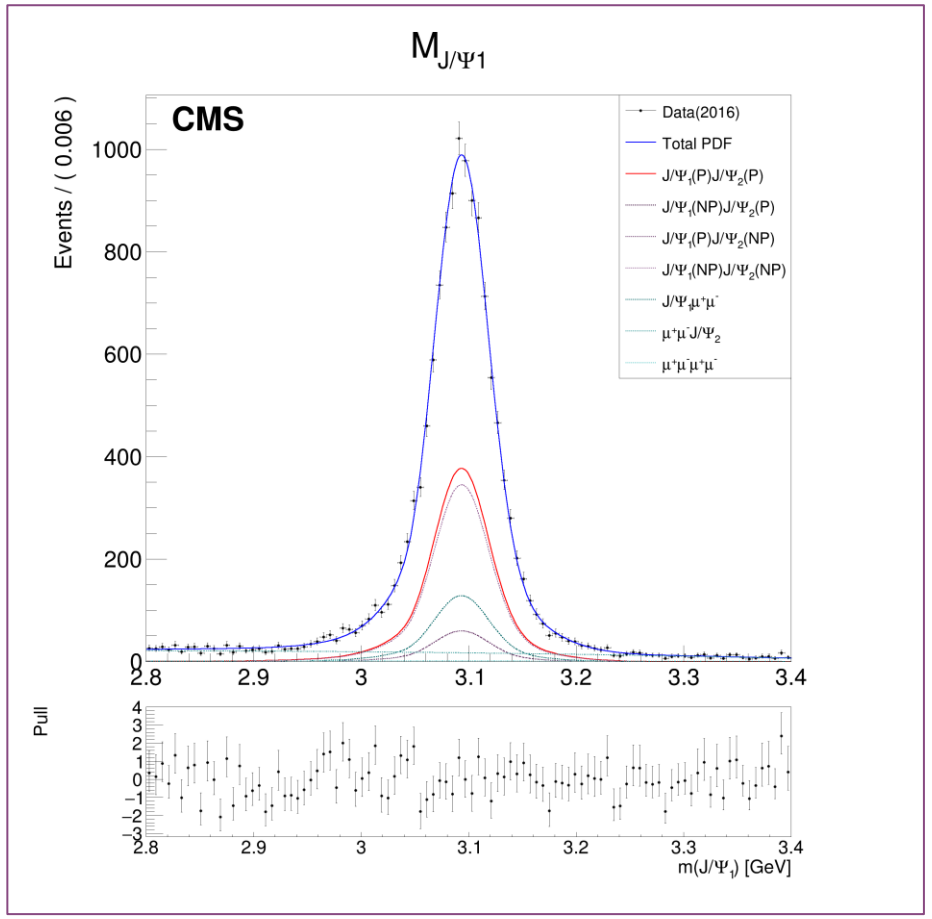
- 2. Append MC samples to the dataset

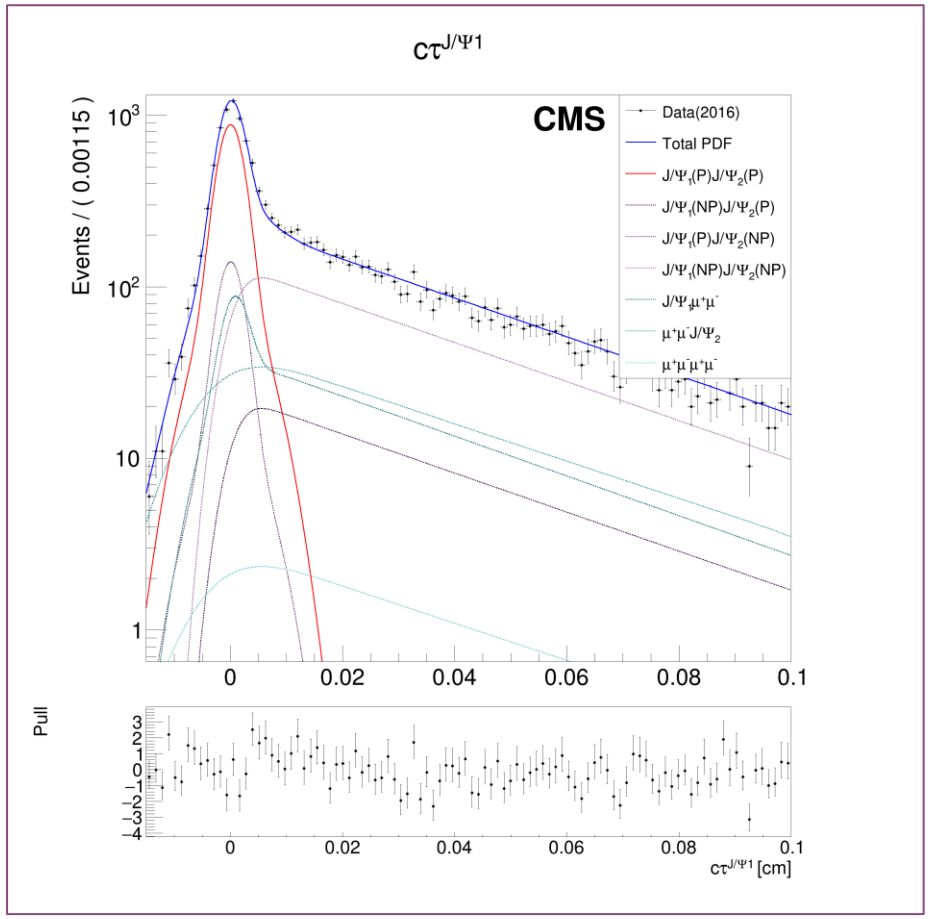
	0	1	2	3	4	5
SPS	-	2000	-	-	2000	2000
DPS	-	-	1000	-	1000	1000
B decay	-	-	-	2000	-	2000

$J/\psi_1 J/\psi_2$	P+P	2630 ± 60	4640 ± 70	3520 ± 70	2630 ± 60	5530 ± 80	5530 ± 80
	NP+P	750 ± 30	730 ± 30	790 ± 30	750 ± 30	770 ± 30	770 ± 40
	P+NP						
	NP+NP	4280 ± 90	4240 ± 90	4250 ± 90	6070 ± 100	4230 ± 90	6040 ± 100
$J/\psi_1 \mu^+\mu^-$		1600 ± 40	1620 ± 40	1620 ± 40	1600 ± 40	1630 ± 40	1630 ± 40
$\mu^+\mu^- J/\psi_2$							
$\mu^+\mu^-\mu^+\mu^-$		110 ± 30	120 ± 30	110 ± 30	120 ± 30	120 ± 30	130 ± 30

Fitting validation

- 3. Append generated samples to the dataset
  - Pseduo-dataset is generated by p.d.f. acquired from MC/sideband
  - Pseduo-dataset is embedded to the original dataset





2K P+P to
2016 dataset

Fitting validation

- 3. Append generated samples to the dataset

		0	1	2	3	4	5	6	7	8
J/ψ_1 J/ψ_2	P+P	-	2000	-	-	-	-	1000	1000	1000
	P+NP	-	-	500	-	-	-	500	-	500
	NP+NP	-	-	-	2000	-	-	2000	-	2000
$J/\psi\mu^+\mu^-$		-	-	-	-	1000	-	-	1000	1000
$\mu^+\mu^-\mu^+\mu^-$		-	-	-	-	-	100	-	100	100

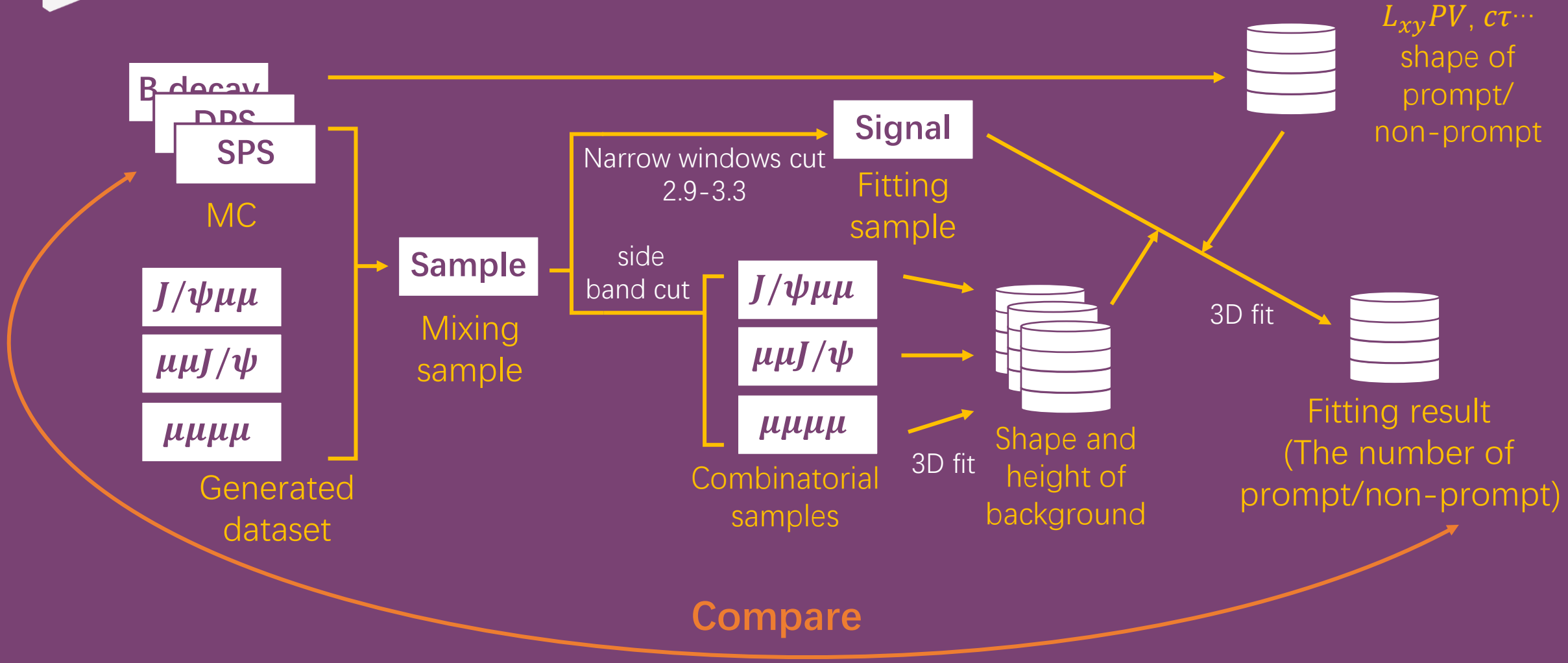
J/ψ_1 J/ψ_2	P+P	2630 ± 60	4670 ± 70	2620 ± 60	2630 ± 60	2630 ± 60	2630 ± 60	3630 ± 70	3630 ± 70	3620 ± 70
	NP+P	750 ± 30	740 ± 30	1260 ± 40	760 ± 40	730 ± 30	750 ± 30	1230 ± 40	740 ± 30	1230 ± 40
	P+NP									
	NP+NP	4280 ± 90	4270 ± 90	4260 ± 90	6270 ± 100	4270 ± 90	4270 ± 90	6300 ± 100	4270 ± 90	6220 ± 110
$J/\psi_1\mu^+\mu^-$		1600 ± 40	1590 ± 40	1600 ± 40	1590 ± 50	2620 ± 50	1580 ± 40	1600 ± 50	2600 ± 60	2630 ± 50
$\mu^+\mu^-J/\psi_2$										
$\mu^+\mu^-\mu^+\mu^-$		110 ± 30	110 ± 20	110 ± 30	110 ± 30	100 ± 30	250 ± 30	120 ± 30	240 ± 30	260 ± 30

Fitting validation

- Three tests have been carried out
- All the results are expected
- The stability of the fitting strategy has been demonstrated

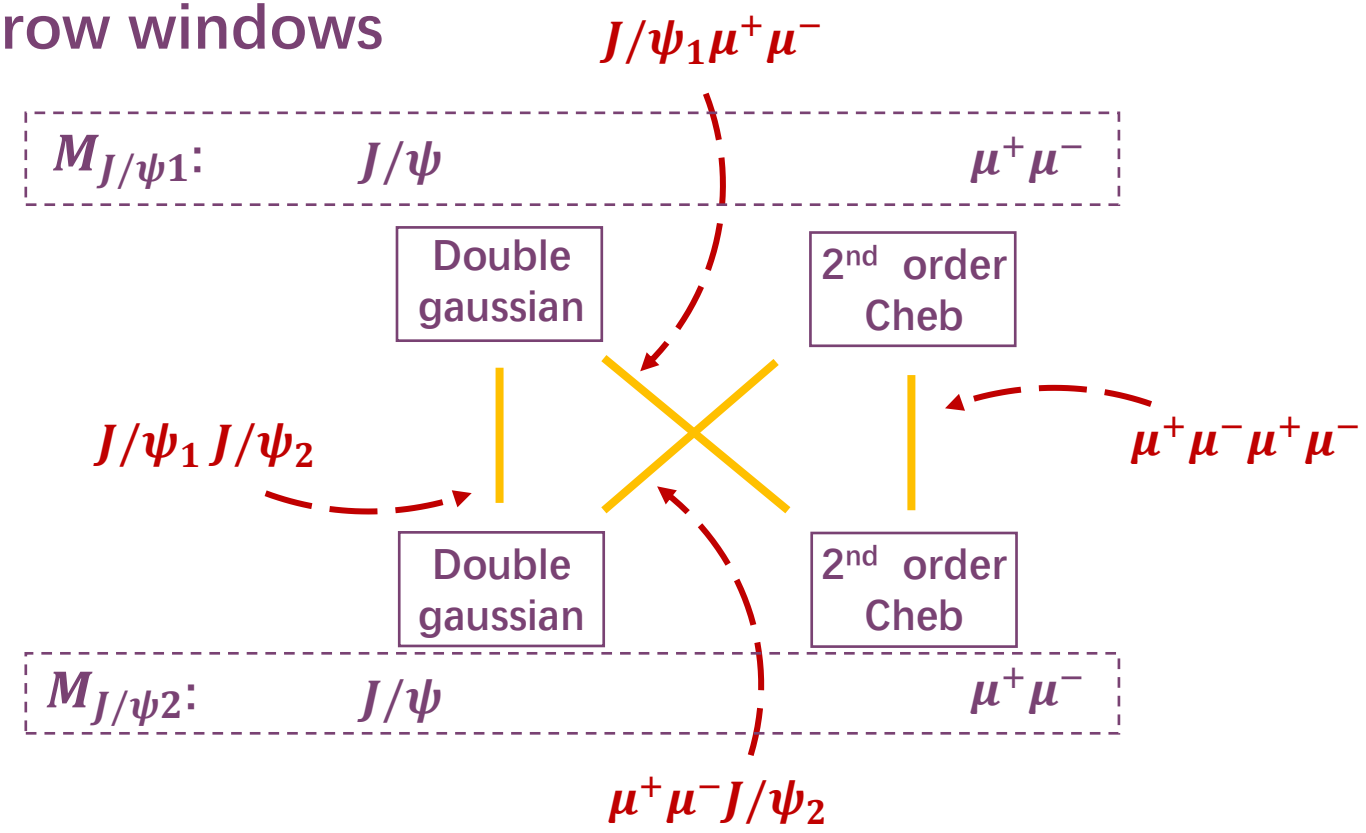
Back Up

Study of the combinatorial background



Fitting to the artificial sample

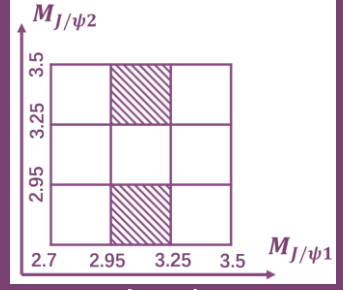
- The side band can be noticed in the “narrow” mass windows: directly fit in the narrow windows



11.17

- The shape parameters of mass dimensions are left to float
- The distributions of lifetime dimensions of the combinatorial background are determined by the sub-range dataset

Fitting procedure

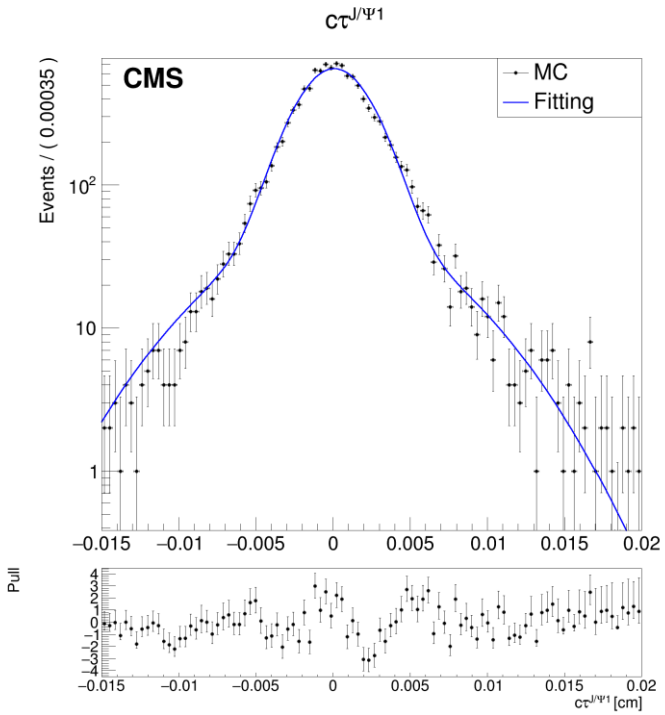


- Mix SPS and DPS samples into the prompt sample (8K:4K)
- 1D fit to the prompt sample on the $c\tau_1$ dimension to acquire the **shape1** (double gaussian)
- 1D fit to the non-prompt sample on the $c\tau_1$ dimension to acquire the **shape2** (convolution of an exponent and a gaussian)
- 1D fit to the prompt sample on the $M_{J/\psi 1}$ dimension to acquire the **shape3** (double CB)
- 1D fit to the data sample on the $M_{J/\psi 1}$ dimension to acquire the **shape4** (second order Cheb, the fitting is applied with a merging of the float Cheb and the **shape3**)
- Side band cut to the data sample to acquire the combinatorial background ($J/\psi_1\mu^+\mu^-$)
- 1D fit to the $J/\psi_1\mu^+\mu^-$ on the $c\tau_1$ dimension to acquire the **shape5** (merging of a gaussian and a convolution)
- 1D fit to the $J/\psi_1\mu^+\mu^-$ on the $c\tau_2$ dimension to acquire the **shape6** (convolution of an exponent and a gaussian)
- **Final fitting**

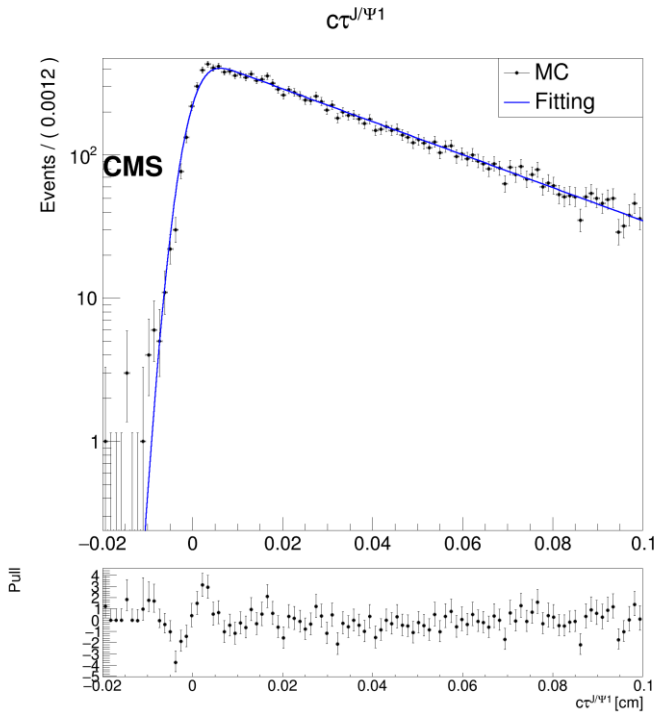
Final fitting

Components		$M_{J/\psi 1}$	$M_{J/\psi 2}$	$c\tau_1$	$c\tau_2$	N
$J/\psi_1 J/\psi_2$	P+P	Double CB	Double CB	Shape1	Shape1	$N_{JJ(PP)}$
	NP+P			Shape2	Shape1	$N_{JJ(PNP)}$
	P+NP			Shape1	Shape2	
	NP+NP			Shape2	Shape2	$N_{JJ(NPNP)}$
$J/\psi_1 \mu^+\mu^-$		Double CB	Shape4	Shape5	Shape6	$N_{J\mu\mu}$
$\mu^+\mu^- J/\psi_2$		Shape4	Double CB	Shape6	Shape5	
$\mu^+\mu^-\mu^+\mu^-$		Shape4	Shape4	Shape6	Shape6	$N_{\mu\mu\mu\mu}$

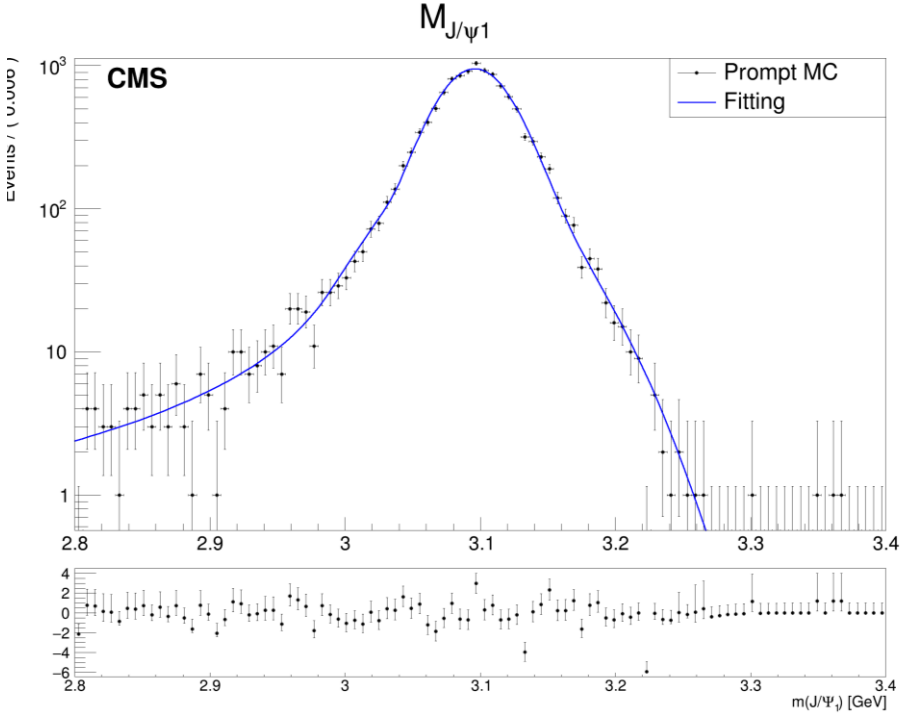
- The functions that share the same name listed in the table also share the same set of parameters (because of the smearing between two J/ψs)
- The parameters for the shape1/2/4/5/6 are fixed from the previous fitting
- The parameters for the double CB are float
- All the heights are float



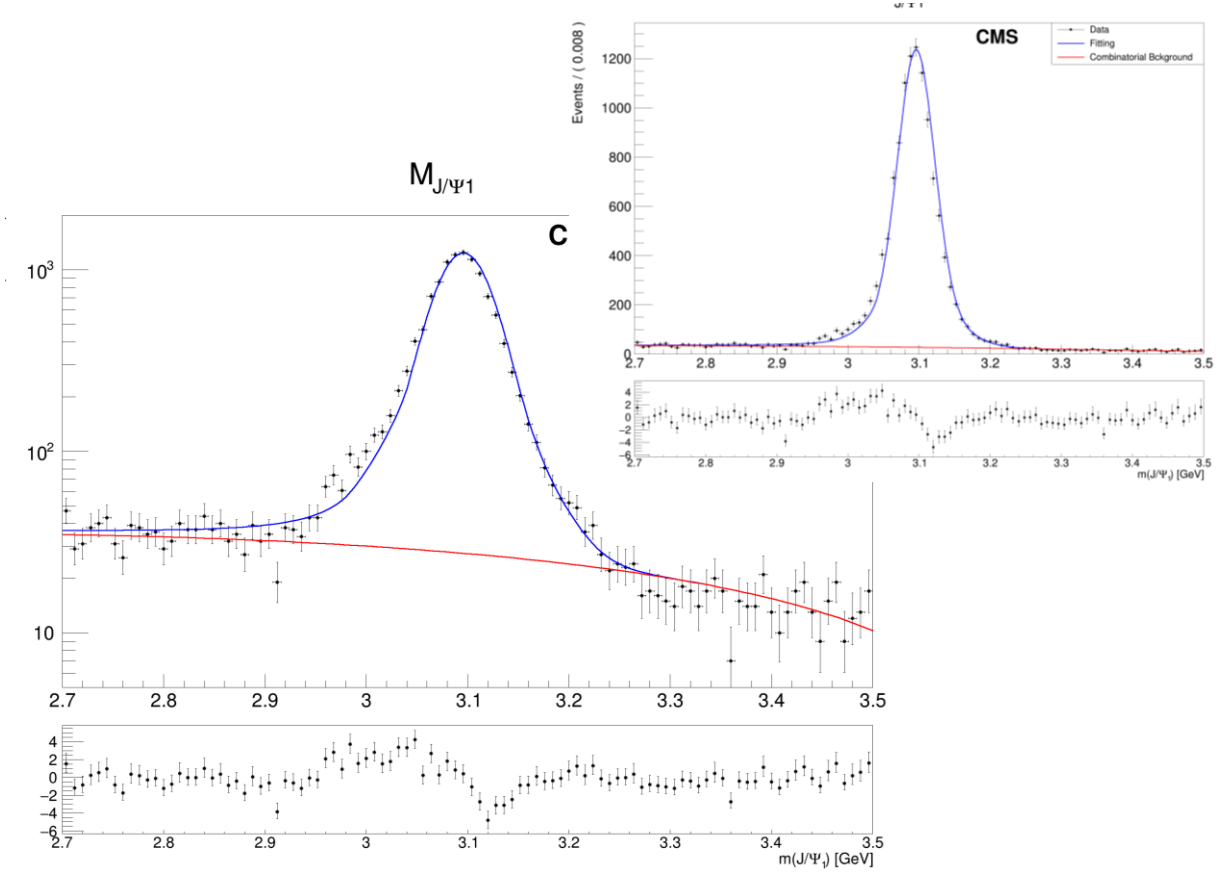
Shape1, the prompt MC on the $c\tau_1$ dimension, double gaussian



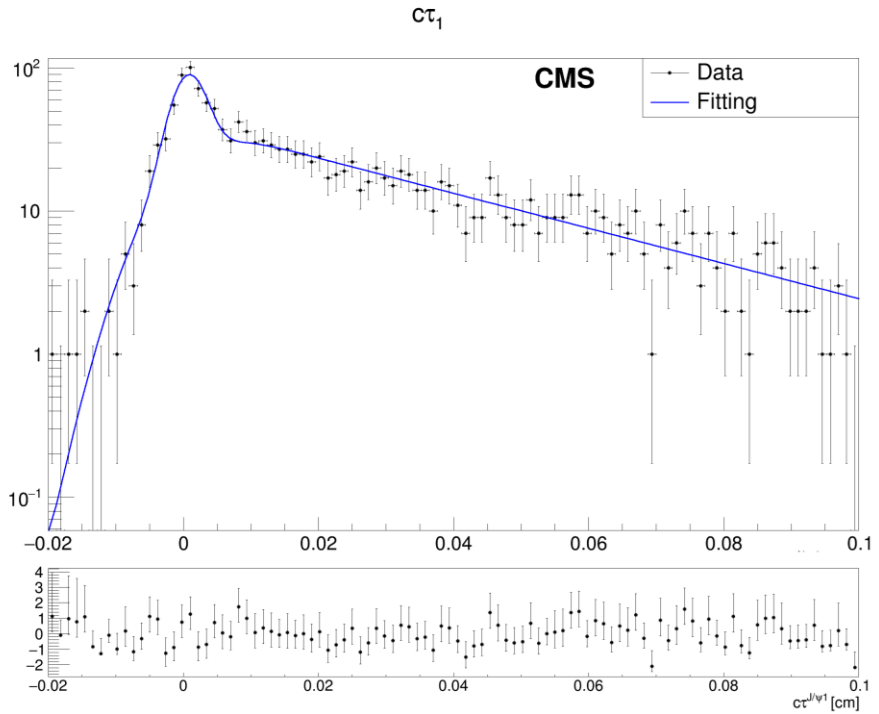
Shape2, the non-prompt MC on the $c\tau_1$ dimension, convolution



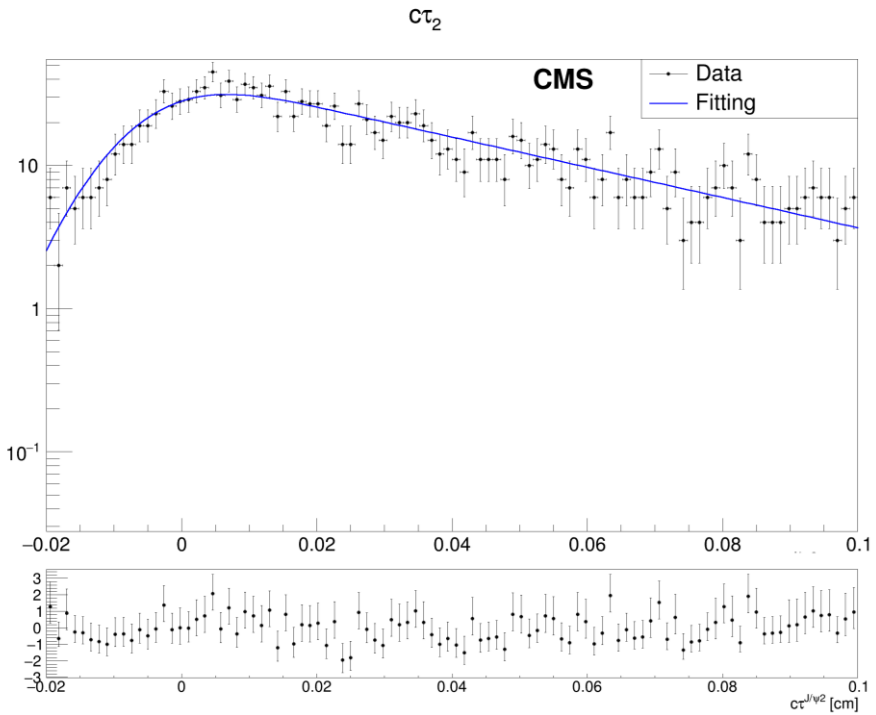
Shape3, the prompt MC on the $M_{J/\psi 1}$ dimension, double CB



Shape4(red line), the data sample on the $M_{J/\psi 1}$ dimension, second order Chebyshev



Shape5, the $J/\psi_1\mu^+\mu^-$ on the $c\tau_1$ dimension, gaussian + convolution



Shape6, the $J/\psi_1\mu^+\mu^-$ on the $c\tau_2$ dimension, convolution